(12) UK Patent Application (19) GB (11) 2 009 845 A

(21) Application No 7847282
(22) Date of filing
5 Dec 1978
(23) Claims filed
5 Dec 1978
(30) Priority data
(31) 2754373
(32) 7 Dec 1977
(33) Fed Rep of Germany
(DE)
(43) Application published
20 Jun 1979
(51) INT CL² F02M 37/00
55/00 // 69/00
(52) Domestic classification
F1B 12G10A 12G15X
12G16 12G2C 12G30
12G3A 12G3C 12G4A
12G5C 12G6B 12G8B
12G8X 12G9F 12G9P
2M5C 2M7
(56) Documents cited
GB 1501156
GB 1485410
(58) Field of search
F1B

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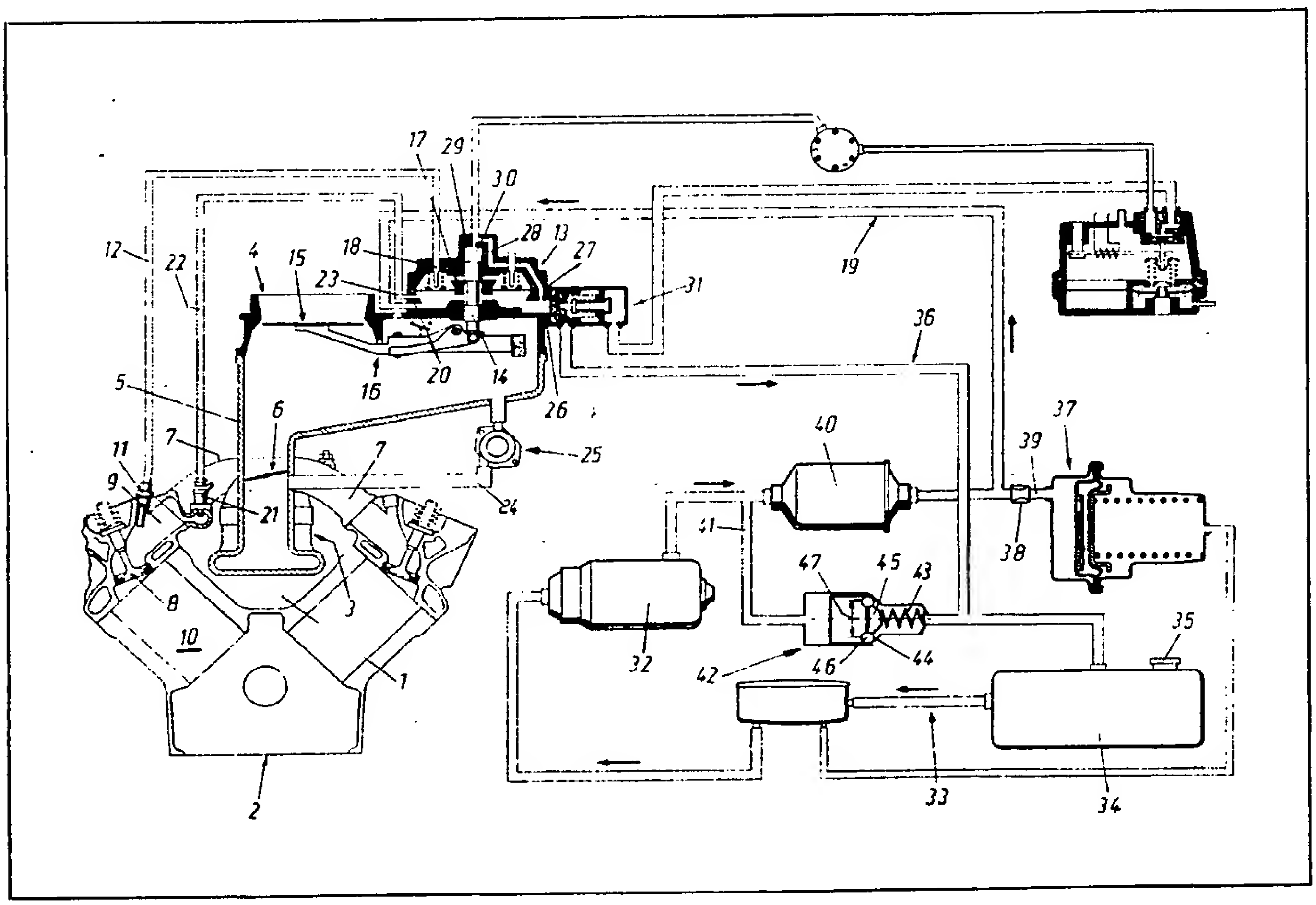
(54) A fuel injection system for an internal combustion engine

(57) The fuel supply pressure pipe 19 is subjected to the pressure of an auxiliary pressure source, the fuel tank 34, by a pressure compensating device 41, 42. The system operates by measuring by means of plate 15 the flow of combustion air and adjusting the quantity of fuel injected accordingly by adjusting a control valve 14 the system including a cold start device 14 independently operable of the normal injection device 11. A fuel pressure accumulator 37 is provided to compensate pressure losses due to leaks in the pipe system.



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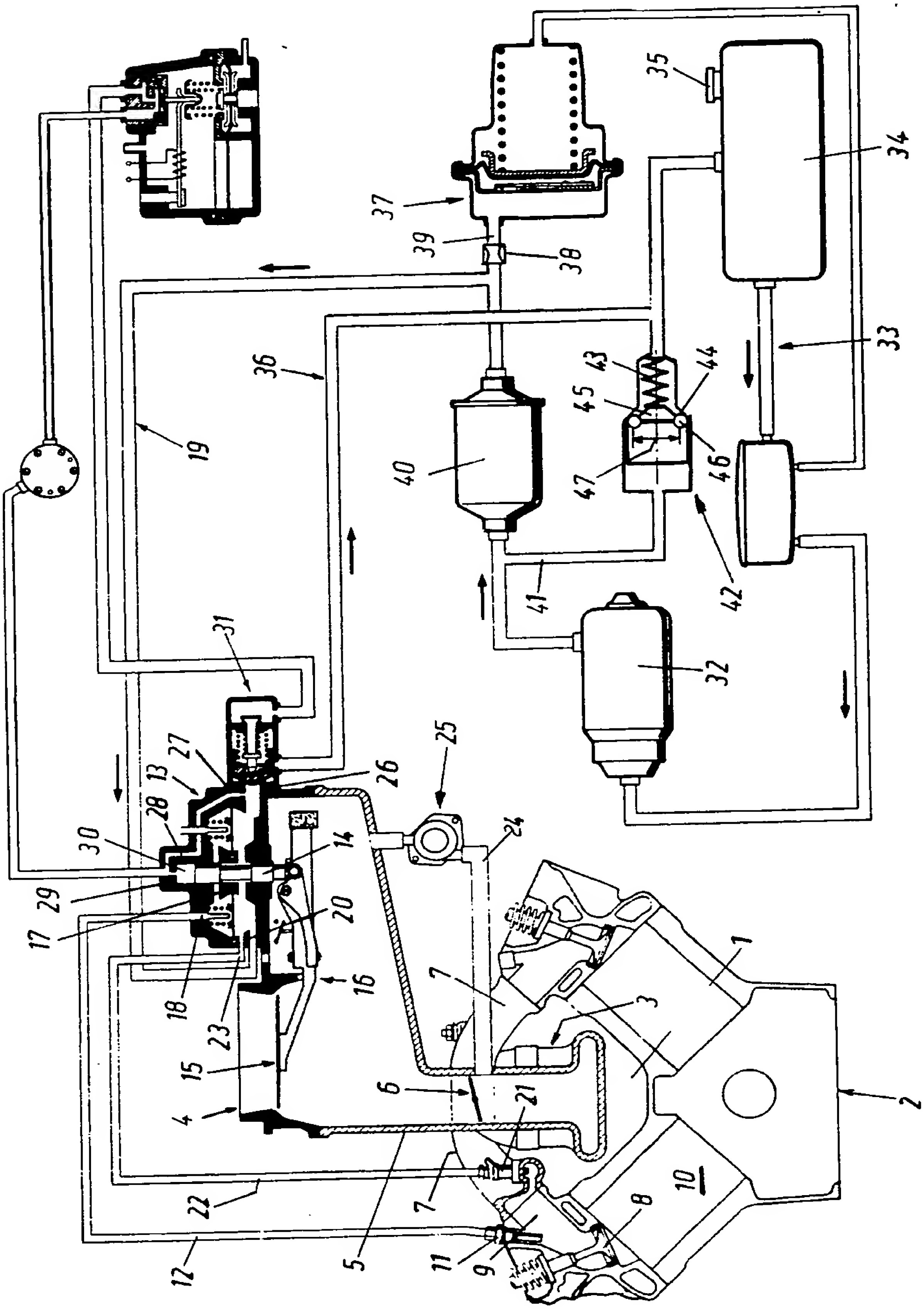
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SPECIFICATION

A fuel injection system for an internal combustion engine

The invention relates to a fuel injection system for an internal-combustion engine, the system including an independently operable cold start device.

Fuel injection systems for internal-combustion engines in which the quantity of fuel to be injected is controlled by air quantity measurements are known (e.g., the engines with K-Jetronic injection) (Jetronic is a Registered Trade Mark). It has been observed in the case of such engines that although the engine fires immediately the starter is actuated, it then stops again after briefly gaining speed. In some circumstances restarting of the engine can only be achieved after a fairly long actuation of the starter. On the basis of the studies which led to the invention, this disadvantage can be explained in the following way:

When the engine is started from cold, fuel and air in the required mixture proportions are supplied by the cold starting device which is controlled as a function of warming-up conditions independently of the normal injection valve, so that immediate firing of the engine is ensured. But due to leaks and/or volume contraction of the fuel dictated by the temperature in the, inherently closed, fuel pipe system, the fuel pressure of that system may have fallen to such low values before the cold starting that the fuel system pressure has still now been brought to the opening pressure of the injection valves at the time of the transition from operation of the cold starting device to operation of the normal injection valves, so that the engine stalls again. This delay in the reaction of the injection valves can be further intensified by the fact that the fuel control pressure has also not yet reached its necessary value for the cold starting position of the control valve at the time of starting the cold engine owing to insufficient system pressure, so that the inherently closed fuel pipe system is then opened towards the injection valves by the control valve which has then not yet assumed its starting position.

Lastly, the engine may also stall during cold starting due to an excessively rich fuel-air mixture. For even at very low external temperatures, the fuel control pressure is very low due to leaks and to volume contraction dictated by temperature, and the control valve responds sluggishly due to the temperature-dictated smaller movement play of its adjusting member in the corresponding valve guideway and the increased viscosity of the fuel. Now if, at insufficient fuel control pressure due to volume contraction of the fuel in the closed fuel pipe system, the control valve is moved by atmospheric pressure out of the cold starting position into an incorrect regulating position which permits an excessive supply of fuel, then a too rich mixture will be supplied to the engine during starting.

According to the present invention there is provided a fuel injection system for an internal-combustion engine, including at least one injection valve for normal service conditions and a cold start device supplying the required cold starting mixture in the cold starting phase, a control valve for adjusting the quantity of fuel supplied to the injection valve as a function of the quantity of combustion air supplied, which control valve can be brought, in response to a fuel control pressure derived from the system pressure of a fuel supply pipe system closed at an engine speed approximating to zero, into a starting position in which the fuel supply to the injection valve is prevented, the fuel pipe system being adapted to be positively subjected to the pressure of an auxiliary pressure source by a pressure compensating device operative in response to the system pressure when the system pressure has fallen below an admissible value.

In the system according to the invention, a required value of the system pressure is positively ensured in the closed fuel pipe system through the pressure compensating device, whereby not only is the control valve maintained in its starting position after the engine is switched off until a subsequent cold start, but also a rapid build up of the system pressure to and beyond the opening pressure of the injection valve is ensured.

A pressure accumulator, e.g., operating with a different pressure medium than fuel —e.g., with compresses air—could serve as auxiliary pressure source, in which case presure-transmitting known separating pistons are included between the pressure pipe system and the compressed air pipe system. Such auxiliary pressure accumulators which are still effective after the switching off of the injection-type internal-combustion engine are frequently already present in motor vehicles, e.g., for acuating central interlock devices.

The actuation of the pressure compensation device in the system according to the invention may occur mechanically (e.g., spring power), electrically (e.g., solenoid) or pnemuatically (e.g., vacuum capsule).

In order to compensate pressure losses due to leaks in the pipe system or fuel evaporation it is known to connect the fuel pipe system for supplying the injection valves which maintains the system pressure to a fuel pressure accumulator. Owing to the restricted accumulator volume of the latter and owing to the leaks which occur due to unavoidable production tolerances, such a fuel pressure accumulator can only compensate the pressure losses occurring over a relatively short period—e.g., of about two hours in the case of a specific production engine. This means that the operating capacity of the accumulator is exhausted

in the case of a cold start. Now in order to prevent a delayed pressure build-up by the charging of the accumulator in the inherently closed fuel pipe system during cold starting, said fuel pipe system may be connected to a fuel pressure accumulator through a throttled fuel-carrying connection to compensate pressure losses in the pipe system.

In the fuel installations of vehicles precautions are taken in customary manner to ensure that the pressure in the fuel-carrying parts of the installation is maintained at atmospheric pressure, in order to prevent damage to the installation resulting from pressure differentials which occur and to permit fuel volume variations as a function of temperature.

Although a value of the fuel control pressure corresponding approximate to the atmospheric pressure is sufficient to bring the control valve into its starting position, it is advantageous if a fuel reservoir unit positively subjected to at least atmospheric pressure serves as the auxiliary pressure source.

In order to avoid particular pressure-transmitting separating means between the fuel pipe system maintaining the system pressure and the fuel unit, it is advantageous if a fuel connection between the auxiliary pressure source and the fuel pipe system maintaining the system pressure can be established through the pressure compensating device.

Preferably, a nonreturn valve opening towards the fuel pipe system and spring-loaded against the system pressure is included in a fuel pressure compensating pipe connecting the fuel pipe system maintaining the system pressure to the auxiliary pressure source.

In motor vehicles, the fuel tank is maintained at atmospheric pressure, but generally arranged in a position relatively remote from the internal-combustion engine. In order to obtain short pipe distances for the pressure equalisation device, it is advantageous if the fuel pressure compensating pipe is connected through a fuel return pipe to the auxiliary pressure source.

A preferred embodiment of the invention will now be described by way of example with reference to the accompanying drawing which shows, schematically a V-8 engine operated with K-Jetronic petrol injection.

The V-space 1 between the two banks of the V-8 engine 2 contains an air admission manifold pipe 3 which is supplied with filtered atmospheric combustion air through an air inlet 4. The combustion air passes from the air inlet 4 through a central air admissin fitting 5 which is controlled by an arbitrarily operable throttle flap 6, into the air admission manifold pipe 3. At points downstream of the throttle flap 6, curved individual admission pipes 7 each from the air admission manifold pipe 3, to an admission duct 9 of a cylinder 10 controlled by an inlet valve 8. Fuel which is fed through an injection pipe 12 from a fuel quantity divider 13 is injected into the admission duct 9 by an injection valve 11 operating under normal conditions. A control slide valve 14 which adjusts the quantity of fuel per unit time of the injection pipe 12, and which is actuated by a stagnation plate 15 measuring the quantity per unit time of the combustion air entering the air admission fitting 5 through a lever linkage 16 operates in the fuel quantity divider 13. In doing so the control slide valve 14 causes a variation of the passage cross-section of a fuel connection 17 provided in the fuel quantity divider 13 between a fuel outlet 18 connected to the injection pipe 12 and a fuel inlet 20 on the fuel quantity divider 13 connected to a fuel pressure pipe 19.

For starting the engine 2 from cold a solenoid-actuated cold starting injection valve 21 is provided which supplies the individual admission pipes 7 with fuel as a function of warming-up conditions. The cold starting injection valve 21 is supplied through an injection pipe 22 which is connected to an associated fuel outlet 23 of the fuel quantity divider 13. The fuel outlet 23 communicates openly with the fuel inlet 20. The fuel injected by the cold starting injection valve 21 receives the combustion air through a neutral air pipe system 24 connected to the admission air pipe sytem 3, 7, the throttle flap 6 being bypassed, and is controlled by a supplementary air control valve 25 operating as a function of warming-up conditions.

There is also provided in the fuel quantity divider 13 a fuel pressure duct 26 communicating openly with the fuel inlet 20, from which there is branched through a throttle 27 a fuel control pressure duct 28 which is connected by a further throttle 29 to a fuel control pressure chamber 30. The end face of the control slide valve 14 opposite the lever linkage 16 is permanently impinged by the pressure of the chamber 30, so that a control pressure force counteracting the stagnation plate 15 results at the control slide valve, which brings the control slide valve into its illustrated starting position blocking the fuel connection 17 when the engine 2 is switched off.

The fuel pressure pipe 19, in which a constant system pressure is adjustable by a pressure regulating valve acting upon the fuel pressure duct 26, connects the fuel quantity divider 13 to the pressure side of an electrically driven fuel pressure pump 32 which sucks fuel through a fuel admission pipe 33 out of a fuel tank 34. The pressure in the tank 34 is maintained at least at atmospheric pressure by a pressure compensation device 35. A fuel return pipe 36 starts from the pressure regulating valve 31 and leads to the fuel tank 34 and is hence likewise subject to some atmospheric pressure.

Because the control slide valve 14 is moved into its starting position when the engine

speed tends towards zero, after the engine has been switched off the fuel pressure pipe 19 constitutes a closed fuel pipe system maintaining the system pressure, in which pressure losses due to leaks or fuel evaporation are compensated over a certain period of time by a fuel pressure accumulator 37 which is branched from the fuel presure pipe 19 through a fuel branch pipe 39 containing a throttle 38. A fuel filter 40 is included in the fuel pressure pipe 19 in order to clean the fuel to be injected. That section of the fuel pressure pipe 19 lying between fuel pump 32 and fuel filter 40 is connected through a fuel pressure compensating pipe 41 to the fuel return pipe 36. A non-return valve 42 which exhibits a closing cone 45 co-operating with a conical valve seat 44 counter to a spring 43 and carries a ring seal 46 is included in the fuel pressure compensating pipe 41. The closing cone 45 is influenced by two oppositely directed and approximately equal sized fuel pressure surfaces determined in their pressure-impinged area by the diameter 47 of the ring seal 46, of which the pressure surface impinged by the system pressure of the fuel pressure pipe 19 operates in the closing sense counter to the spring 43. This valve design ensures that the spring 43 positively opens the valve cone 45 when the system pressure of the fuel pressure pipe 19 has fallen to the pressure of the fuel return pipe 36—i.e., approximately to atmospheric pressure. Consequently no volume contraction of the fuel can occur in the fuel pressure pipe 19 when the fuel pressure accumulator 37 has discharged after the engine 2 is switched off and the fuel cools intensely due to low external temperatures. The fuel control pressure surface on the control slide valve 14 which is operative for the starting position is so dimensioned that a system pressure approximately of the value of atmospheric pressure in the fuel pressure duct 26 is sufficient to build up the required fuel control pressure in the chamber 30 through the throttles 27 and 29, which constitutes the adjusting force necessary for the starting position at the control pressure surface.

The assurance of the starting position of the control slide valve 14 achieved positively by the fuel pressure compensating device 41, 42 is particularly important for cold starting, because in this case the injection valves 11 which operate under normal conditions must be switched off so as not to be able to interfere either with the function of the cold starting device 21, 24, 25 or with the rapid build-up of the system pressure by the pump 32 to the required service value. It is furthermore particularly advantageous that during the building-up of the system pressure the delaying effect of the fuel pressure accumulator 37 is eliminated by its separation from the fuel pressure pipe 19 by means of a throttle 38. For the trouble-free operation of the cold starting device 21, 24, 25 achieved by the invention ensures a rapid speeding-up of the engine so that a high system pressure must be available at the control slide valve without delay for the service readiness of the normal injection valves 11 in order to avoid stalling of the engine due to a poor transition from service of the cold starting device to service of the normal injection valves.

CLAIMS

1. A fuel injection system for an internal-combustion engine, including at least one injection valve for normal service conditions and a cold start device supplying the required cold starting mixture in the cold starting phase, a control valve for adjusting the quantity of fuel supplied to the injection valve as a function of the quantity of combustion air supplied, which control valve can be brought in response to a fuel control pressure derived from the system pressure of a fuel supply pipe system closed at an engine speed approximating to zero into a starting position in which the fuel supply to the injection valve is prevented, the fuel pipe system adapted to be positively subjected to the pressure of an auxiliary pressure source by a pressure compensating device operative in response to the system pressure when the system pressure has fallen below an admissible value.

2. A fuel injection system according to claim 1, wherein said fuel pipe system is connected to a fuel pressure accumulator through a throttled fuel-carrying connection to compensate pressure losses in the pipe system.

3. A fuel injection system according to claim 1 or claim 2, wherein a fuel resorvoir unit positively subjected to at least atmospheric pressure serves as the auxiliary pressure source.

4. A fuel injection system according to claim 1, 2 or 3, wherein a fuel connection between the auxiliary pressure source and the fuel pipe system maintaining the system pressure can be established through the pressure compensating device.

5. A fuel injection system according to any one or more of claims 1 to 4, wherein a nonreturn valve opening towards the fuel pipe system and spring-loaded against the system pressure is included in a fuel pressure compensating pipe connecting the fuel pipe system maintaining the system pressure to the auxiliary pressure source.

6. A fuel injection system according to any one or more of claims 1 to 5, wherein the fuel pressure compensating pipe is connected through a fuel return pipe to the auxiliary pressure source.

7. A fuel injection system according to any one of claims 1 to 6 wherein the auxiliary pressure source is a fuel tank.

8. A fuel injection system for an internal

combustion engine substantially as described herein with reference to and as illustrated in the accompanying drawings.

Printed for Her Majesty's Stationery Office
by Burgess & Son (Abingdon) Ltd.—1979.
Published at The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.